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Spatial Geometry of Channel Bar Deposits of Mississippi River, United States of America

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Abstract

This paper present the result of a first ever study on geometry of channel bar deposits of Mississippi River of United States of America, based on remote sensing and GIS. In this study 31 channel bar deposits and their geometry have been documented. This study indicates that overall the Mississippi River is a meandering channel within the study area. The geometries of channel bar deposits documented are linear, crescent-shaped, curved crescent-shaped, globular and tabular. In the studied part of the Mississippi River channel, the linear and crescent-shaped bar deposits are predominant than the other shapes. The coefficient of determination (r^2) result suggests that there are an average correlativity between the width and length of channel bar deposits. Remote sensing studies has provided useful information on specific shape and size ranges of bar deposits from Mississippi River channel which can be utilized as an input for more efficient characterization and development of hydrocarbon reservoirs occurring in ancient fluvial channel bar deposits.

Keywords: Fluvial channel deposits, Channel bar geometry, Remote sensing, GIS, Mississippi river, America.

Introduction

Petroleum industry is going through a very tough time due to quite lower prices of crude oil. The lower crude oil price has led many exploration projects postponed or closed down. To manage such downtime in industry, companies now require to do research and development to innovate and bring down their exploration and productions costs so that they manage such low crude oil price time period now and in coming future.

Fluvial channel bar deposits (point bars, channel bars, crevasse splay) having sandy composition are important hydrocarbon reservoirs worldwide [ex. Reservoir of Travis Peak Formation, East Texas (Davies et al. 1991); Fall River sandstone reservoir, Northeastern Wyoming (Berg, 1968)]. So it is important to understand the external geometry of such channels bars in characterizing and developing hydrocarbon reservoirs efficiently (Payenberg et al., 2003) and economically. Meandering rivers deposit sand and mud within well defined meander belts

(Shepherd, 2009). Macroforms found in meander belts include point bars, crevasse splays, and mud-rich channel plugs within a background of floodplain muds. Coals are found in fluvial systems with high water tables (Gibling, 2006).

The understanding of geometry of channel bar is important because of the following reasons: 1. Due to resolution such channel bars may not be distinguished on seismic data; 2. Drilled wells are many hundred meters apart which also can miss channel bars. Here remote sensing as a low cost technique is suitable for studying modern fluvial channels which provide important and useful information on size and shape of channel bar deposits. The findings of such study can be utilized in ancient fluvial channel deposits as an input in characterization and development of hydrocarbon bearing reservoirs.

Evaluation of published work has shown few literatures (Miall, 1985; Tucker, 2003) in which some information on spatial geometry of channel bars has been provided. Miall (1988) studied the outcrops of deposits of fluvial systems for understanding the geometry of fluvial deposits and utilizing them in exploration and exploitation of hydrocarbon reservoirs. However all fluvial outcrops are not completely exposed on the surface to document and study their external geometry. In such conditions study of modern fluvial systems using remote sensing and GIS can help to generate important information on channel bars and their geometry. The present study documents channel bar deposits and their geometry from Mississippi River channel, and study the relationship between the width and length of channel bar deposits. The purpose of present study is to provide a cost effective technique, in the form of remote sensing, for extracting information on size and shape of channel bar deposits which can aid in cost efficient exploration and characterization of ancient fluvial hosted hydrocarbon reservoirs.

Study Area

The study area (Fig. 1) is 474880 km^2 of United States of America through which Mississippi River traverses and the geographic coordinates of the study area is 30°41'21.00"N - 37°22'39.00"N and 87°21'1.00"W - 94°36'14.00"W.

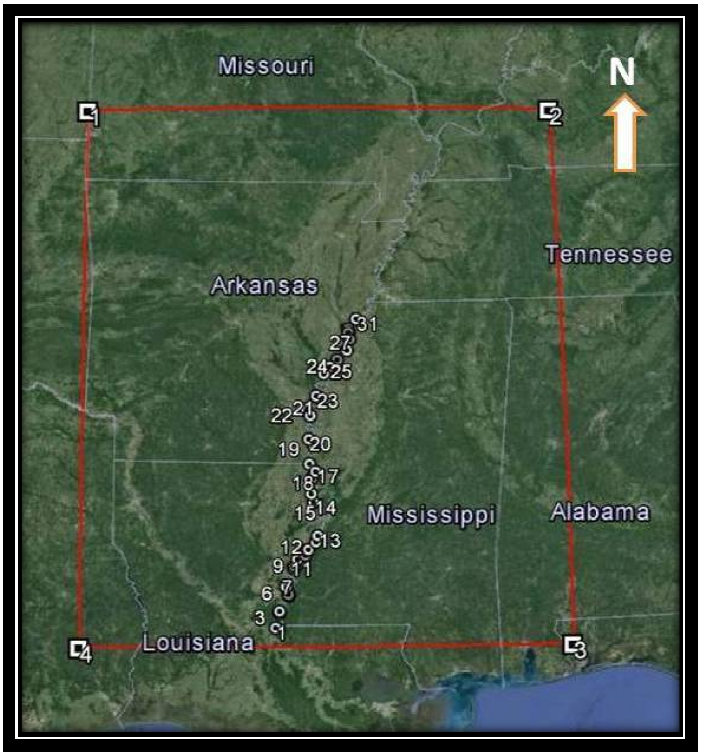

Fig. 1. Satellite imagery showing the study area demarcated by red lines and identified channel bar deposits in Mississippi river channel

Materials and Methods

Google Earth imageries and Google Earth Pro Geographic Information System (GIS) provide an analytical framework for imagery data synthesis that combines a system capable of visualizing, analyzing, synthesizing, integrating and representing spatial data. Google Earth Pro GIS support the following data like point, line, path, polygons, including filled

Table 1. Width and length of channel bar deposits.

S.N. of bar deposits	Bar length (m)	Bar width (m)	S.N. of bar deposits	Bar length (m)	Bar width (m)
1	2861	611	17	4359	1087
2	2586	390	18	3853	1052
3	3666	482	19	5349	2251
4	1983	332	20	3391	587
5	1970	344	21	5832	2254
6	3957	1161	22	3697	1308
7	5335	727	23	4233	1125
8	4209	843	24	2102	561
9	2306	643	25	3622	946
10	4174	831	26	3109	891
11	1522	559	27	3763	814
12	4700	1809	28	4376	1666
13	3342	538	29	2611	456
14	3045	588	30	3225	785
15	4048	1433	31	4936	1924
16	5219	657			

polygons; and measurement of distance and area utilizing these functions like any other GIS software. Google Earth Pro uses Simple Cylindrical projection with a WGS84 datum for its imagery base. The imageries archived in the Google Earth have spectral mode in natural colour and ortho-rectified.

In this study archived satellite images from Google Earth have been used. Apart from this, the Google Earth Pro GIS software has been utilized to measure and present the quantitative data on channel bar deposits. The term channel bar includes all those sediments deposited inside the channel. The main types of channel bars are point bars, middle bars and alternate bars. The length of the channel bar is determined as the distance between the two terminal points along a bar. The width of the channel bar is defined as the maximum length between the two end-to-end points across a bar. Sinuosity index, length and width of the channel bars have been measured from the imageries using Google Earth Pro GIS software.

Results and Discussion

The sinuosity index of Mississippi River channel within study area was determined. Sinuosity index was measured using the formula of Schumm (1963), the ratio of the channel length to the valley length. Within the study area, the channel length is 1149 km and valley length is 768 km. The channel sinuosity index found to be 1.49, which indicates that the Mississippi River channel within the studied area is a meandering channel. The results on the length and width of channel bar deposits are shown in Table 1.

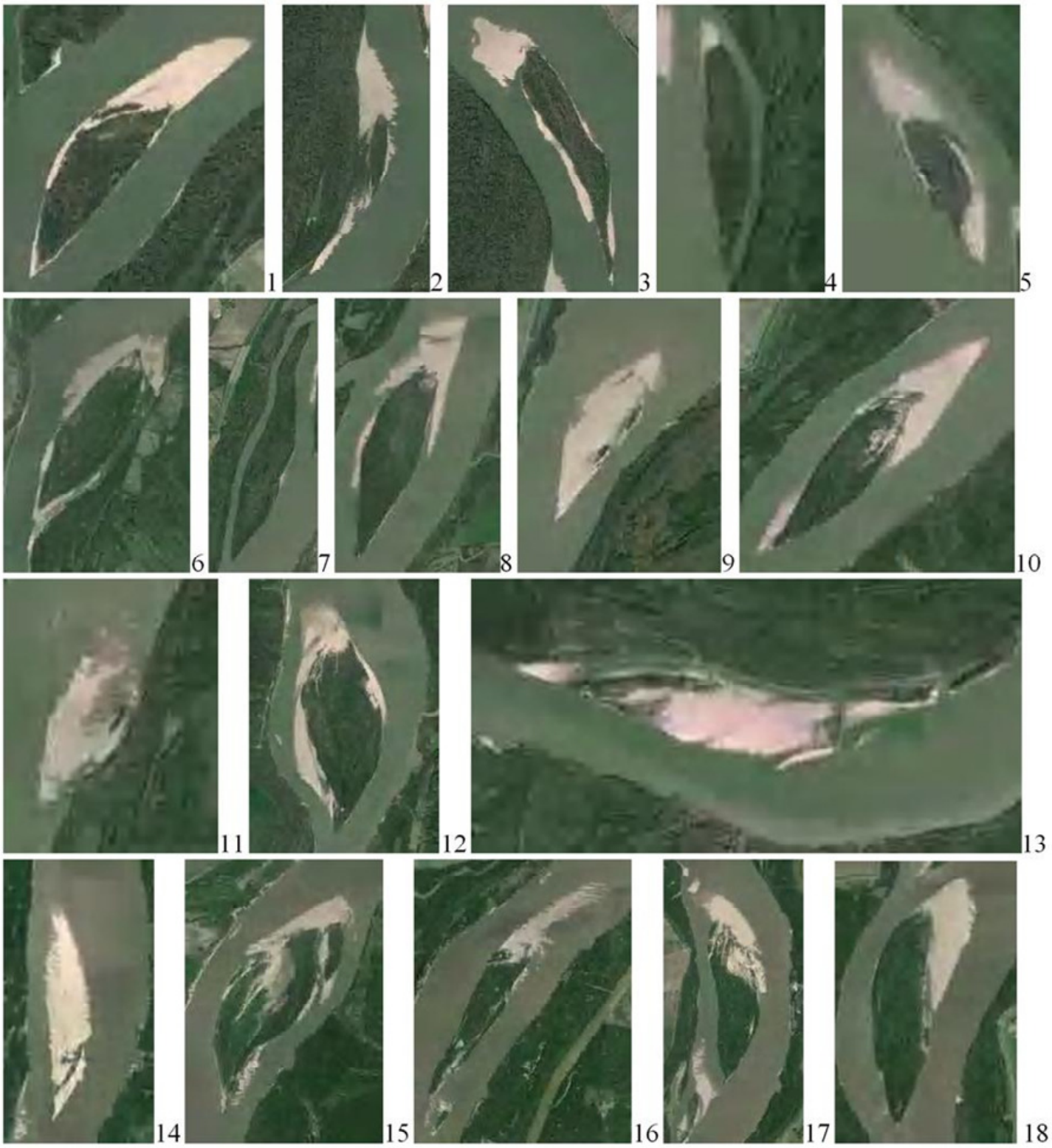

Fig. 2. 1. Crescent 2. Curved crescent 3. Linear 4. Linear 5. Linear 6. Tabular 7. Linear 8. Linear 9. Linear 10. Linear 11. Crescent 12. Globular 13. Crescent 14. Linear 15. Globular 16. Linear 17. Crescent 18. Crescent.

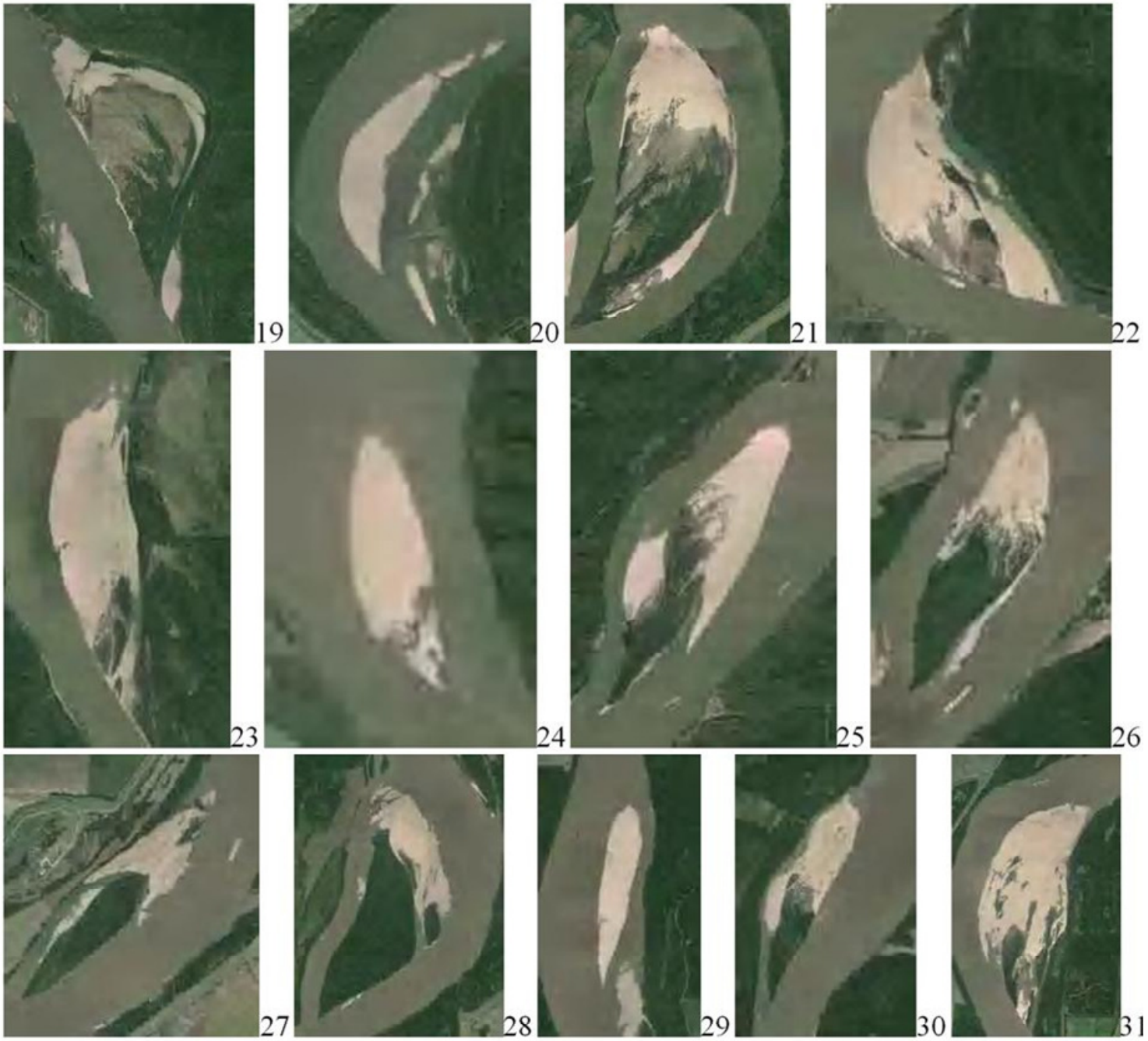

Fig. 3. 19. Crescent 20. Curved crescent 21. Crescent 22. Curved crescent 23. Crescent 24. Linear 25. Linear 26. Linear 27. Linear 28. Crescent 29. Linear 30. Linear 31. Crescent.

Channel bar deposits and their geometry

Based on interpretation of satellite imagery, 31 channel bar deposits have been documented in the fluvial channel of the study area (Fig. 1, 2, 3). Overall the studied channel is meandering as indicated by the sinuosity index of 1.49. However, locally it has characteristics of a straight channel also. In general, geometries like sheet, lens, wedge, scoop, U – shaped has been mentioned in the literatures (Miall, 1985). Tucker (2003) provided some information on geometries of sedimentary deposits.

For bed/rock unit geometry terminology information like tabular, wedge shaped and lenticular has been provided. However, the documented geometries of channel bars from Mississippi River show more diversity. The geometries of channel bar deposits documented are linear, crescent-shaped, curved crescent-shaped, globular and tabular. In the studied part of the Mississippi River channel, the linear and crescent-shaped bar deposits are predominant than the other shapes. This finding is not mentioned in any earlier published literatures (ex. Berg, 1968; LeBlanc, 1972; Miall, 1985; Davies et al. 1991; Payenberg et al. 2003; Tucker, 2003; Gibling, 2006; Shepherd, 2009).

The channel bar length and width data (Table 1) were cross-plotted and their coefficient of determination (r^2) was determined (Fig. 4). The coefficient of determination (r^2) between the channel bar lengths and width is 0.539. A value of 0.539 suggests the correlativity between the length and width of the channel bars is not so significant. Overall, no general relationship has been found between the length and width of the geometry of the studied channel bar deposits. Thus, predictivity is less utilizing length of a channel bar deposit to predict its width or using width to predict their length. This necessitates more detail characterization of specific channel bar deposits. This finding is also not mentioned in any earlier published literatures (ex. Berg, 1968; LeBlanc, 1972; Miall, 1985; Davies et al. 1991; Payenberg et al. 2003; Tucker, 2003; Gibling, 2006; Shepherd, 2009).

Lithological interpretation of channel bar deposits

Documented channel bar deposits were studied for their lithological aspects interpreting satellite imageries. Sand bar deposits were interpreted based on light to bright tone, white colour and coarse texture. However, some parts were found to be of relatively darker tone, fine textured which may be either due to finer sand or clay/silt. Relatively dark tone may be due to moisturisation. Relatively darker tone parts may be due to wet condition by presence of water.

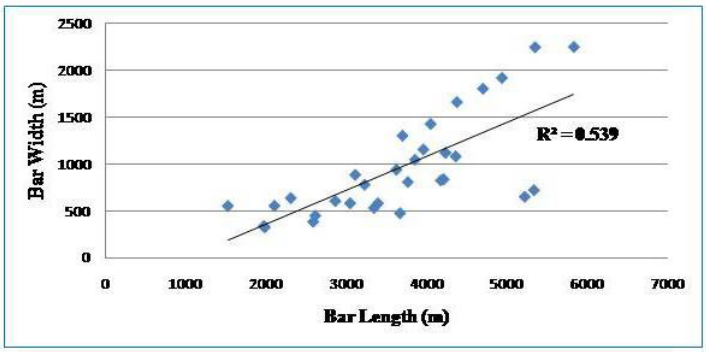

Fig. 4. Cross plot between the length and width of all channel bars.

Conclusions

This study indicates that overall the Mississippi River is a meandering channel. In this study 31 channel bar deposits and their geometry have been documented. The geometries of channel bar deposits documented are linear, crescent-shaped, curved crescent-shaped, globular and tabular. In the studied part of the Mississippi river channel, the linear and crescent-shaped bar deposits are predominant than the other shapes.

The coefficient of determination result suggests that there are no relationships between the width and length of channel bar deposits. Thus, predictivity is less in utilizing length of a channel bar deposit to predict its width or using width to predict its length. This has important implication in the study of meandering channel bar deposits as, until and unless more detail data are available, the relative width and length of a channel bar deposit cannot be predicted easily. Remote sensing studies provides useful information on geometry of channel bar deposits, from modern fluvial systems, which can be utilized as an input, as an analog, for more efficient

characterization and development of hydrocarbon reservoirs occurring in ancient fluvial channel bar deposits.

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